

Lunar Exploration Science Objectives

Outline

- Goals for future lunar exploration
 - What do we want to know about the Moon?
- Current Activities to develop payloads
 - CubeSats – SIMPLEx-2
 - Instrument Development efforts – DALI
 - STMD technology interests
- What payloads are available?
 - NASA Internal Payloads
 - NASA Lunar Science Technology Investigations Program

Science Goals: Guiding Documents

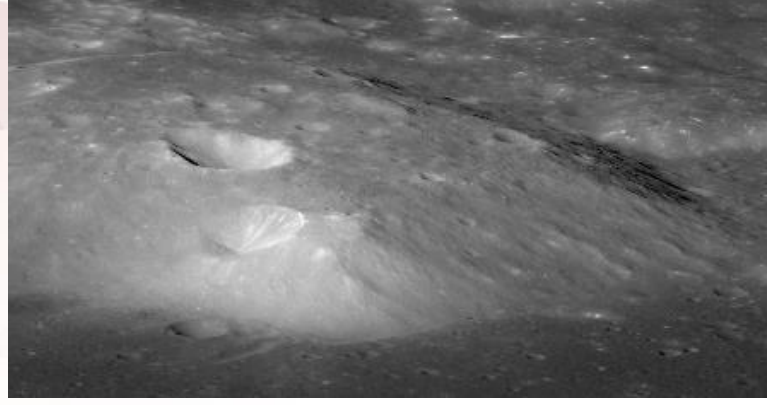


- LEAG Reports
 - Advancing Science of the Moon (ASM-SAT)
 - Next Steps on the Moon (NEXT-SAT)
 - LEAG United States Lunar Exploration Roadmap (US-LER)
- Lunar Science for Landed Missions Workshop
 - Talks and report archived here:
<https://lunar-landing.arc.nasa.gov/>
- Survive and Operate Through the Night Workshop
 - Report Available on LEAG Website
- <http://www.lpi.usra.edu/LEAG>

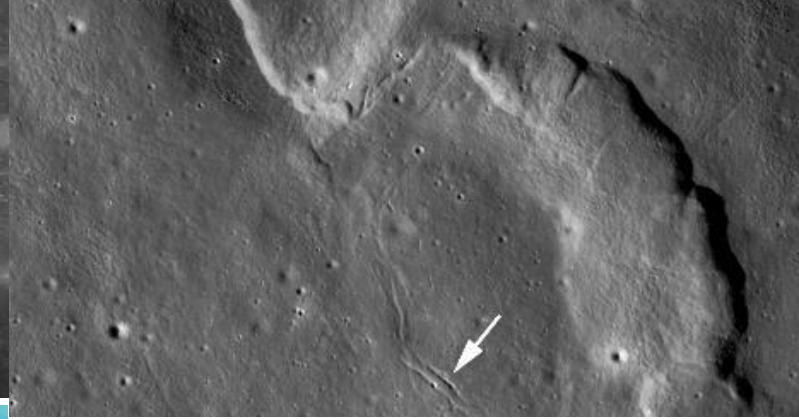
New Advances

- The Moon is the Cornerstone of the Solar System
 - Apollo fieldwork and samples are the foundation of all planetary science
- New understanding from recent lunar missions: Kaguya, LRO, LCROSS, Chandrayaan-1
- The Moon offers opportunities for profound advancements in our understanding of the Solar System and universe around us

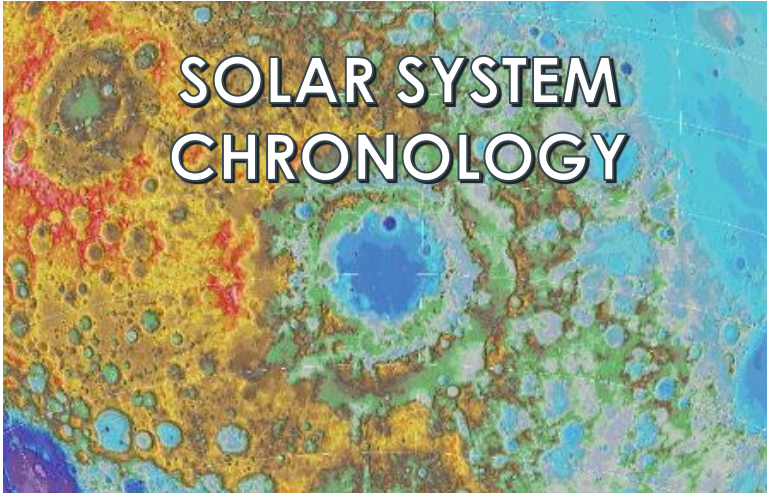
PLANETARY VOLCANISM



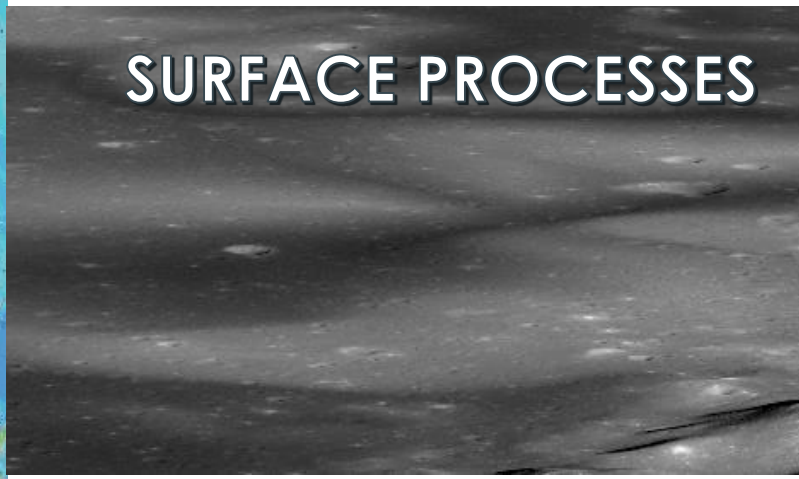
PLANETARY TECTONICS



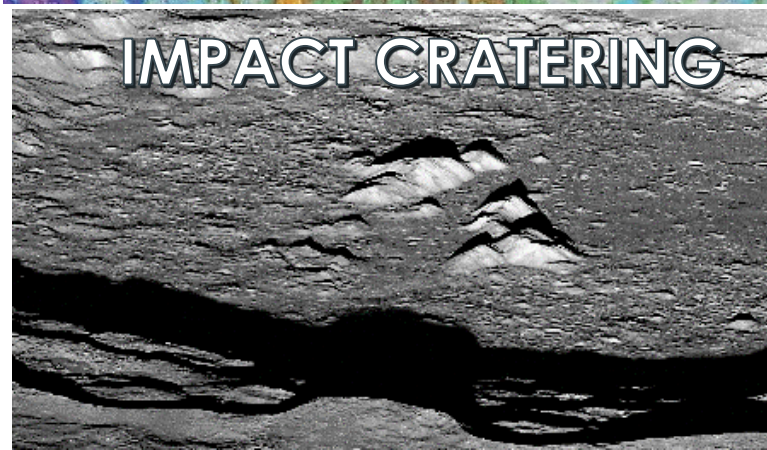
SOLAR SYSTEM
CHRONOLOGY



SURFACE PROCESSES



IMPACT CRATERING



RESOURCE EXPLORATION



Small Innovative Missions for Planetary Exploration (SIMPLEx)

- SIMPLEx-2 Concept Selections include a lunar mission concept, Lunar Trailblazer
- Potentially available for potential delivery by commercial lander service provider
 - Ride along under CLPS; providing additional opportunities for commercial companies
- <https://www.jpl.nasa.gov/news/news.php?feature=7431>

Space Technology Mission Directorate Interests

- STMD is responsible for technology development from early stage innovation through maturation and on to demonstration
- STMD expects to utilize CLPS for technology demonstration payloads. Examples of potential technology demonstration payloads include:
 - Precision landing and hazard avoidance
 - Power generation: solar and fission
 - In situ resource utilization
 - Cryogenic fluid management for propulsion systems and in situ propellant production
 - Autonomous operations and sensing
 - Advanced avionics
 - Mobility and mechanisms
 - Advanced materials

STMD Point-of-contact: Andrew Petro andrew.j.petro@nasa.gov

DALI (Development and Advancement of Lunar Instrumentation)

- 10 Selections made Feb 2019
- Lunar instruments that support NASA's broader lunar exploration goals, including human exploration and in situ resource utilization (ISRU), as well as lunar science
- See list here:
- <https://www1.grc.nasa.gov/space/planetary-exploration-science-technology-office-pesto/management/dali/>

NASA Payload Selections

- Payloads that are ready, or nearly ready, to fly.
- 12 Selections made February 2019
 - The Linear Energy Transfer Spectrometer will measure the lunar surface radiation environment.
 - Three resource prospecting instruments:
 - The Near-Infrared Volatile Spectrometer System is an imaging spectrometer that will measure surface composition.
 - The Neutron Spectrometer System and Advanced Neutron Measurements at the Lunar Surface are neutron spectrometers that will measure hydrogen abundance.
 - The Ion-Trap Mass Spectrometer for Lunar Surface Volatiles instrument is an ion-trap mass spectrometer that will measure volatile contents in the surface and lunar exosphere.
 - A magnetometer will measure the surface magnetic field.
 - The Low-frequency Radio Observations from the Near Side Lunar Surface instrument, a radio science instrument, will measure the photoelectron sheath density near the surface.
 - Three instruments will acquire critical information during entry, descent and landing on the lunar surface, which will inform the design of future landers including the next human lunar lander.
 - The Stereo Cameras for Lunar Plume-Surface Studies will image the interaction between the lander engine plume as it hits the lunar surface.
 - The Surface and Exosphere Alterations by Landers payload will monitor how the landing affects the lunar exosphere.
 - The Navigation Doppler Lidar for Precise Velocity and Range Sensing payload will make precise velocity and ranging measurements during the descent that will help develop precision landing capabilities for future landers.
- See list here:
 - <https://www.nasa.gov/press-release/nasa-selects-experiments-for-possible-lunar-flights-in-2019>

NASA Lunar Science Technology Investigations Program

- 12 Instruments Selected 1 July 2019
- Selections:
 - MoonRanger
 - Heimdall
 - Lunar Demonstration of a Reconfigurable, Radiation Tolerant Computer System
 - Regolith Adherence Characterization
 - Lunar Magnetotelluric Sounder
 - Lunar Surface Electromagnetics Experiment (LuSEE)
 - Lunar Environment Heliospheric x-ray imager (LEXI)
 - Next Generation Lunar Retroreflectors
 - Lunar Compact Infrared Imaging System
 - Lunar Instrumentation for Subsurface Thermal Exploration with Rapidity (LISTER)
 - PlanetVac
 - Sample Acquisition, Morphology Filtering, and Probing of Lunar Regolith
- See list at:
 - <https://www.nasa.gov/press-release/nasa-selects-12-new-lunar-science-technology-investigations>

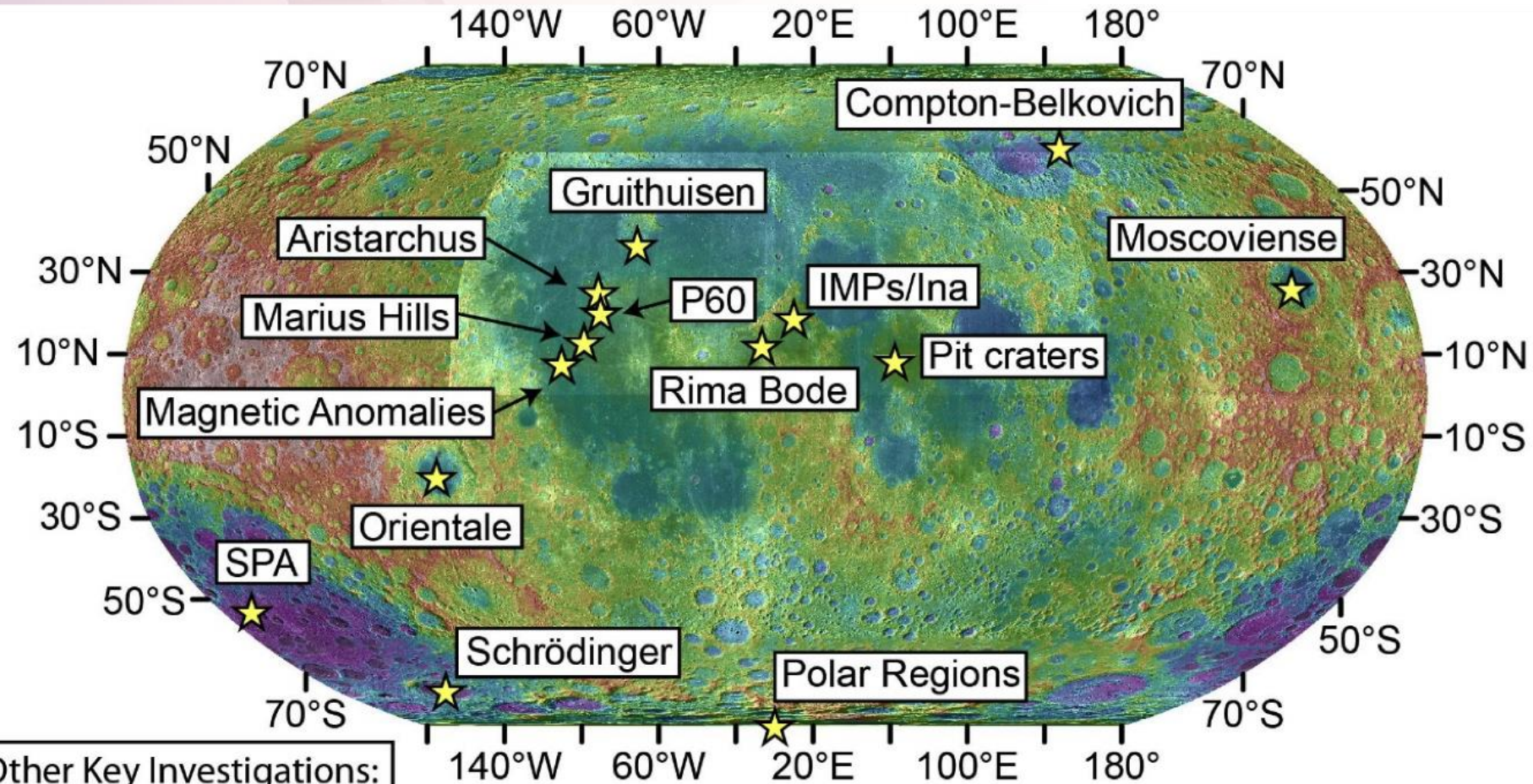
2-Stage Payload Process

- Different from our usual 2-step downselects
- Phase 1 – “get your instrument ready to fly”
 - No guarantee you will fly
 - Selected 24 potential payloads
- Phase 2 – integrate onto a specific flight opportunity
 - Additional funds for integrating, ops, and science
 - Internal process based on factors such as ease of accommodation, readiness timeline, and appropriateness for landing site for the science or technology proposed

Rover Strategy

- Primary drivers include science objectives and soonest landing; target is 2022 and South Pole region
- Primary science objectives: ground truth of volatiles (horizontal and vertical distribution)
 - Polar investigation
 - Long duration operation (months)
- The Volatiles Investigation Polar Exploration Rover (VIPER) will explore the south polar region, using four instruments to acquire new key data on the lateral and vertical distributions of volatiles
 - **Neutron Spectrometer System (NSS)**
 - **Near InfraRed Volatiles Spectrometer System (NIRVSS)**
 - **Mass Spectrometer Observing Lunar Operations (MSolo)**
 - **The Regolith and Ice Drill for Exploring New Terrain (TRIDENT)**

The science community is excited - excellent
Decadal science to be done all over the Moon!!



Other Key Investigations:
Impact Basins
Geophysical Network
Interdisciplinary Science